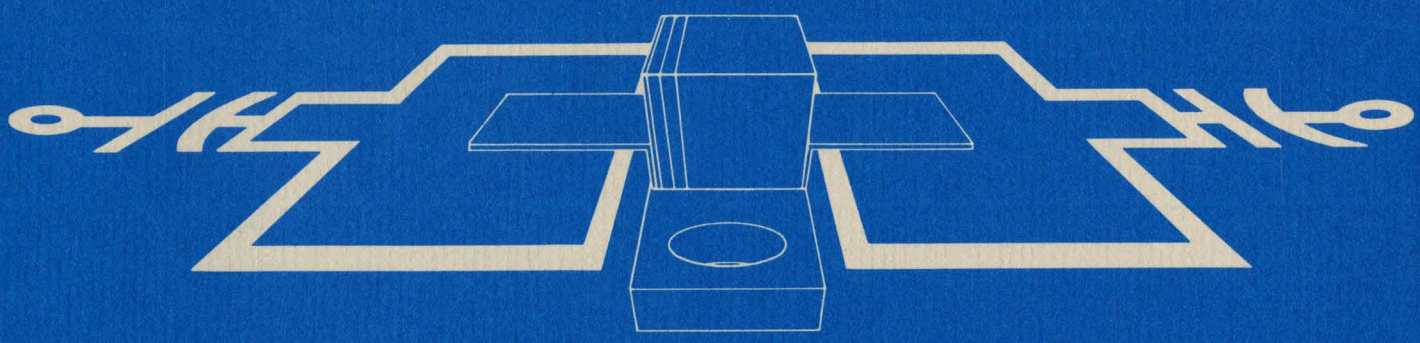
RCA

Microwave Power Transistors



Design Features
Circuit Applications

MPT-700

Optional Price 60 cents

RCA Microwave Power Transistors

During the past several years, the RCA Solid State Division has conducted intensive programs to improve the quality and reliability of microwave power transistors and simultaneously to advance the state-of-the-art power-frequency capability of these devices. The significant technological improvements that have resulted from these programs have advanced microwave power transistors from the level of a mere laboratory curiosity to the point that such devices are now used with confidence in numerous microwave equipments in which high reliability is a prime requisite.

This booklet describes the major design features that make possible the outstanding high-frequency performance and exceptional reliability provided by RCA microwave power transistors. Each new feature incorporated into these transistors has been selected on the basis of a demonstrated contribution to improved device reliability and microwave performance. The basic device selection criteria and circuit design factors that must be considered in power-circuit applications of microwave transistors are also discussed, and examples and performance data are provided for practical power-amplifier and oscillator circuits designed for operation at microwave frequencies.

Design Features

RCA "overlay" silicon power transistors offer significant advantages for high-frequency power applications at frequencies that extend well into the microwave region. The recent technological advances in RCA microwave power transistors are extensions of the RCA overlay-transistor concept. Table I summarizes the major design features currently available in RCA microwave power transistors.

Overlay Transistor Structure

The RCA overlay design,* the basic type of structure used for RCA microwave power transistors, employs a unique emitter construction that makes possible exceptional power-frequency capabilities. The emitter is separated into many discrete sites that are connected in parallel to provide the increased current-handling capability required at high power levels. Fig. 1 shows a photograph of a typical wafer that contains many overlay-transistor pellets and a view, many times enlarged, of a single pellet that shows the

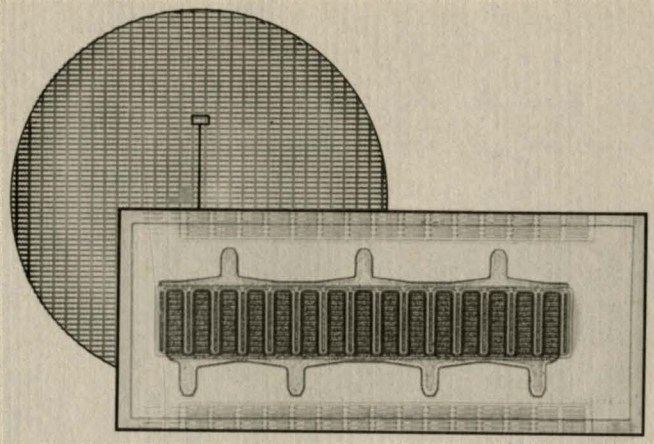


Fig. 1 — Wafer containing an array of overlay-transistor pellets and an enlarged view of a single pellet showing the separate emitter sites.

separate emitter sites. This type of emitter structure provides the high ratio of emitter periphery to base area that is essential to the generation of high power levels at microwave frequencies. In addition, the overlay construction makes possible current densities in the emitter metallizing fingers that are significantly less than those in other high-frequency transistor structures. The adverse effect of high current density on transistor reliability, particularly with respect to failures caused by aluminum migration, has been reported by J. R. Black.(1)

The reduced emitter current density in overlay transistors can be attributed primarily to the relatively broad metal fingers used to interconnect the discrete emitter sites. These fingers are typically an order of magnitude wider than the ones used in interdigitated or mesh types of transistor structures. In addition, the separation between the emitter and base metallized fingers is 3 to 4 times greater than that in other types of high-frequency transistor structures. This increased separation permits the deposition of thicker metallizing layers and, therefore, results in a further reduction in current densities.

Table I — Design Features of RCA Microwave Power Transistors

Feature	Advantages
Overlay structure	Reduces current density Minimizes aluminum migration
Emitter-site ballasting	Reduces formation of isolated hot spots Improves safe operating area Improves transistor resistance to failure under high VSWR conditions
Polycrystalline silicon layer (PSL)	Minimizes "alloy spike" failures Minimizes dielectric failures
Nitride-passivated structure	Improves resistance to dielectric failure at elevated temperature
Glass-passivated aluminum metallizing	Minimizes aluminum migration
Metal-ceramic hermetic package	Improves resistance to moisture Results in rugged mechanical construction Features low inductances and low parasitic capacitances Provided in both stripline and coaxial configurations

*U.S. Patent No. 3,434,019, March 18, 1969

Emitter-Site Ballasting

A major technological development in the evolution of microwave power transistors is a unique process in which an integral series resistor is introduced directly above each emitter site of an overlay transistor structure. RCA uses this process, which is referred to as emitter-site ballasting, to achieve rugged and reliable fine-line precise-geometry microwave power transistors without sacrifice in high-frequency performance.

In overlay transistors, additional conducting and insulating layers can be readily introduced between the aluminum metallization and the shallow diffused emitter sites (shallow emitter diffusion is a requirement for good microwave performance). RCA has developed a technique in which a polycrystalline silicon layer (PSL) is interspersed between these regions. This interlayer, the resistivity of which can be accurately controlled by impurity doping, is used as the medium for the emitter-site ballasting of RCA microwave power transistors. Fig. 2 shows a cross-sectional diagram of an overlay transistor structure that includes the polycrystalline silicon layer.

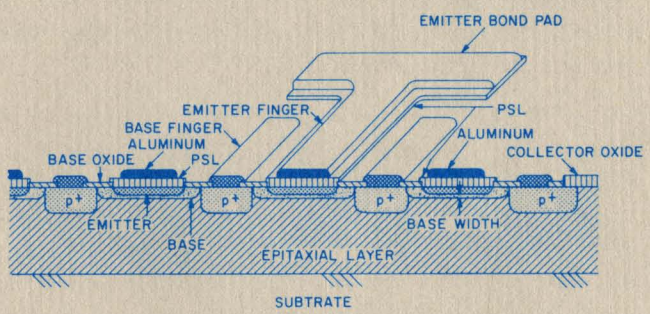


Fig. 2 – Cross-section of an overlay transistor structure that contains the polycrystalline silicon layer (PSL).

The resistivity of the polycrystalline silicon layer and the geometry of the contacting aluminum are controlled to form a ballast resistor in series with each emitter site. This ballasting has proved very effective in the reduction of hot spots, i.e., localized heated areas that result when the emitter-to-collector current is allowed to concentrate within small regions of the transistor pellet. Such current concentrations may occur when a large number of transistor elements are interconnected electrically, but are not coupled thermally. The formation of such hot spots can result in a regeneration action that leads to localized thermal runaway and the consequent destruction of the transistor.

The ballast resistors connected in series with each emitter site provide degenerative feedback to prevent excessive current in any portion of the transistor, and the formation of hot spots is significantly reduced. Because the overlay construction results in an emitter that is segmented into many separate sites connected in parallel, each hot spot may be isolated and controlled so that the injection of charge carriers across the transistor chip is made more uniform.

The emitter-site ballasting results in a more uniform current distribution and, therefore, makes possible more effective utilization of emitter periphery. Consequently, transistor power-output and overdrive capabilities are increased, and the forward-bias safe-operating area (determined by infrared measurements) is enlarged. This latter factor is important for linear applications of microwave power transistors.

The formation of transistor hot spots under rf conditions increases as the output VSWR increases. Transistor failures caused by high VSWR conditions are often related to forward-bias second breakdown, which is characterized by extremely high localized currents. Emitter-site-ballasted transistors, therefore, have a substantially greater immunity to failure produced by high VSWR conditions such as those encountered in some broadband amplifiers. This immunity is particularly demonstrated by two RCA emitter-site-ballasted microwave power transistors, the 2N6265 and the 2N6266, which are characterized to withstand an infinite VSWR at all phases of operation within rated power levels and frequency limits.

Polycrystalline Silicon Layer

In addition to its use as a medium for emitter-site ballasting, the polycrystalline silicon layer (PSL) also helps to minimize two other thermally induced failure modes that occur in high-frequency power transistors. As shown in Fig. 2, this layer forms an insulating barrier between the aluminum metallization and the shallow diffused emitter region and, therefore, substantially reduces the possibility of "alloy spike" failures, i.e., emitter-to-base shorts caused by intermetallic formations of silicon and aluminum that may occur under severe hot-spot conditions.

The polycrystalline silicon layer also provides a barrier between the aluminum emitter finger and the silicon-dioxide insulating layer over the base. This barrier minimizes the possibility of emitter-to-base shorts caused by dielectric failures that result from an interaction between the aluminum and the silicon dioxide.

Recent reliability studies of high-frequency transistors operated under overstress conditions (i.e., at junction temperatures greater than 200°C) demonstrated an order of magnitude improvement in the mean time between failures for types that contain the polycrystalline silicon layer over that of similar types in which this layer is not used. These results verify that the PSL technique contributes substantially to over-all device reliability and therefore is an important feature in the construction of high-frequency power transistors. Consequently, this new feature has been incorporated into the entire line of RCA microwave power transistors.

RCA Microwave Power Transistors

Nitride-Passivated Structure

RCA microwave power transistors include a silicon nitride insulating layer in addition to the normal silicon dioxide layer. Silicon nitride offers a greater resistance to the migration of ionic contaminants than silicon dioxide. Such contaminants migrate down to the silicon surface and induce a negative layer that can result in increased leakage currents or reduced breakdown voltages. The silicon nitride insulating layer acts as a barrier to minimize this condition.

Silicon nitride is also more resistant to reduction by metallization than silicon dioxide. Use of the silicon nitride layer, therefore, reduces dielectric failures that can occur after extended high-temperature operation.

Glass-Passivated Aluminum

In RCA microwave power transistors, a silicon dioxide layer is deposited over the aluminum metallization. This deposition results in an increase of 40 per cent in the activation energy required for the initiation of aluminum migration. The mean time between failure of large crystalline aluminum passivated in this way is increased by approximately four times at a current density of 1×10^5 amperes/centimeter 2.(1) The silicon dioxide layer also protects the aluminum from contamination and from damage that may result because of scratches or smears during device assembly.

Metal-Ceramic Transistor Packages

The package of a power transistor used in microwave applications becomes an integral circuit element that has a critical bearing on over-all circuit performance. A suitable package for a microwave power transistor should have good thermal properties and low parasitic reactances. Package parasitic reactances and resistive losses significantly affect circuit performance characteristics such as power gain, bandwidth, and stability. The most critical parasitics are the inductances of the emitter and base leads. The higher the power capabilities of the transistor, the lower the device impedances, particularly at the input. For high-power microwave transistors, the input impedance is determined primarily by the package, rather than by the transistor pellet. Consequently, high-power microwave transistors should be encased in well-designed and well-constructed packages.

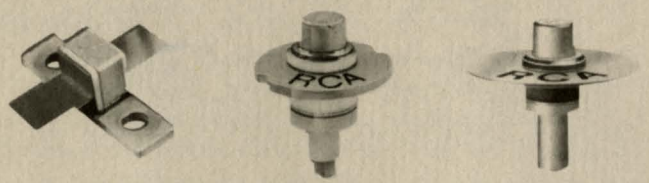
Microwave power transistors are supplied in molded-plastic, glass-frit-sealed, and metal-ceramic packages. The molded-plastic and glass-frit-sealed packages, however, have some inherent disadvantages, and transistors supplied in such packages do not provide the reliability demanded in many microwave power applications.

A basic disadvantage of molded-plastic packages is that they are not truly hermetic. Transistors supplied in molded plastic packages are also subject to bond failures because of thermal expansion and contraction of the junction coating during the cyclic application of power in transmitter service.

The main disadvantage of glass-frit-sealed packages is that they are relatively fragile. These packages, although they do provide a true hermetic enclosure, are more susceptible to mechanical failure than other types of microwave-power-transistor packages.

All RCA microwave power transistors are supplied in metal-ceramic packages. These packages, which are sealed with metallized ceramic interfaces, provide a true hermetic enclosure that can withstand thermal cycling from $-65^{\circ}C$ to $+200^{\circ}C$ and power cycling such as may be encountered in transmitter service. In addition, these packages are mechanically rugged and are essentially impervious to moisture and other external contaminants.

RCA metal-ceramic microwave-transistor packages are supplied in either stripline or coaxial configurations. Fig. 3 shows photographs of an RCA stripline package, the HF-28, and two coaxial packages, the HF-11 (JEDEC TO-215AA) and the HF-21 (JEDEC TO-201AA). In the stripline package, shown in Fig. 3(a), the base is connected directly to the flange. In the coaxial packages, shown in Figs. 3(b) and 3(c), the base is connected to the flange for amplifier units, and the emitter is connected to the flange for oscillator units. In both the stripline and coaxial packages, the base is rf-grounded with very low parasitic lead inductance to minimize output-to-input feedback and to facilitate stable common-base amplifier operation.



HF-28 (a) HF-21 (JEDEC TO-201AA) (b) HF-11 (JEDEC TO-215AA) (c)

Fig. 3 – RCA microwave power-transistor packages: (a) stripline package: (b) coaxial package for use in stripline and lumped-constant microwave amplifier circuits; (c) coaxial package designed for L- and S-band power-oscillator applications.

The RCA metal-ceramic packages are specifically designed to have extremely good thermal properties. For example, the collector lead is made of solid silver, and the pellet is mounted directly to this lead. As a result, the temperature rise in the pellet is significantly reduced because the thermal conductivity of silver is approximately three times that of beryllium oxide, which is normally used as the mounting surface for power-transistor pellets.

In the design of the RCA metal-ceramic packages, every effort is made to minimize the inductance of the bonding wires that connect the pellet to the package. One technique used is that of double bonding in which both ends of the bonding wire are attached to the package, and the center of the wire is attached to the pellet, as shown in Fig. 4. The resultant packages, in addition to being mechanically

rugged hermetic designs with excellent thermal properties, have very low values of parasitic reactances and excellent isolation between input and output. Table II lists the inductances and upper-frequency limits of the three microwave-transistor packages shown in Fig. 3.

Transistor Selection Criteria

Transistors that can generate tens of watts of power output at frequencies up to and beyond 2.3 GHz are finding applications in a wide variety of new-equipment designs. Some of the major applications for these new transistors are in the following types of equipment.

1. Telemetry
2. Microwave relay links
3. Microwave communications
4. Phased-array radars
5. Mobile radio and radio-telephones
6. Navigational aid systems (DME, Collision Avoidance, TACAN)
7. Electronic countermeasures (ECM)
8. Microwave power sources and instrumentation
9. Intrusion-alarm systems

In such equipment, transistors offer the advantages of simplified circuitry, wide bandwidths, and improved reliability, together with reduced size and weight.

The selection of the proper transistor for a specific application is determined by the required power output, gain, and circuit preference. RCA offers the circuit designer a wide variety of microwave power transistors from which to choose the optimum type for a particular application. As mentioned in the preceding section, such transistors are supplied in either coaxial or stripline packages. In addition, transistor types that are optimized for operation from either 22 or 28 volts and that are packaged specifically for either amplifier or oscillator applications are also readily available.

At a frequency of 2 GHz, a single transistor can supply an output power greater than 10 watts with a gain of 7 dB. If higher output power is required, two or more transistors can be connected in parallel, either directly or by use of hybrid combiners. Higher gain can be achieved by connection of several stages in cascade. The transistor supply voltage is usually dictated by the application. In telemetry systems and microwave relay links, the supply voltage normally ranges from 20 to 23 volts; most other systems use 28 volts. The type of package selected, either coaxial or stripline, usually depends on the type of circuit in which the designer plans to use the transistor. The three basic package options for RCA microwave power transistors, shown in Fig. 3, were discussed in the preceding section.

Circuit Applications

In the design of transistor microwave power circuits, several fundamental factors must be considered. These factors include the type of circuit (microstripline, coaxial, lumped element, or combination of these types) to be used; the type of transistor package selected; the required size and type of heat sink; and the power output, gain, efficiency, and bandwidth desired. All these factors are interrelated.

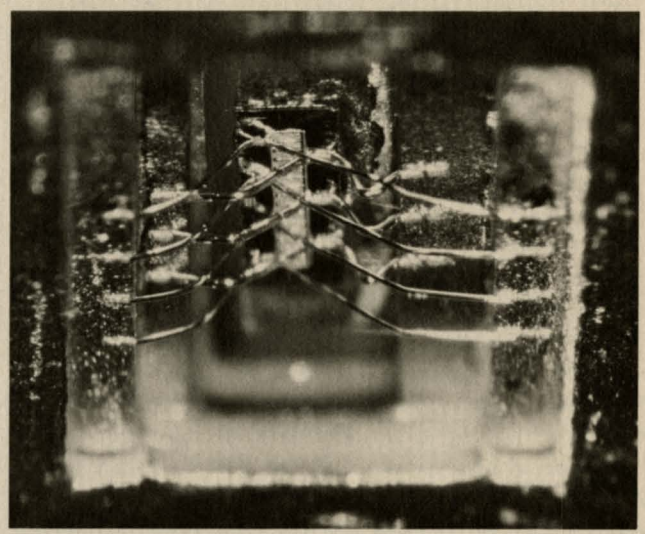


Fig. 4 — Open microwave stripline package showing double bonding of transistor pellet to package.

Table II — Summary of RCA Transistor Packages

Package	Approximate Inductance (nH)	Approximate Frequency Of Operation (MHz)
Microwave Hermetic Stripline HF-28 (Flanged)	0.2	2500
Coaxial Hermetic HF-11 = JEDEC TO-215AA HF-21 = JEDEC TO-201AA	0.1 0.2	3000 2500

RCA Microwave Power Transistors

Typical Circuit Structures

Fig. 5 shows a typical test fixture used for stripline transistors. The base, or flange, is bolted directly to the ground plane of the input and output microstriplines, and the emitter and collector are connected to the top plane of the input and output lines, respectively. Capacitors C1 and C4 provide dc blocking, and capacitors C2 and C3 are rf bypass elements. The input and output microstriplines can be constructed of Teflon, alumina, or any suitable low-loss dielectric material. The input and output of the transistor can be matched directly to 50 ohms by a proper choice of the length and characteristic impedance of the microstriplines or to a low-loss intermediate level with stub tuners used to provide the final transistion to 50 ohms.

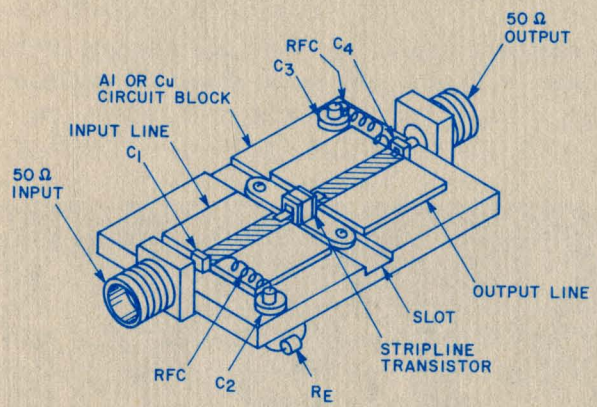


Fig. 5 — Test fixture for stripline-package microwave power transistors.

Fig. 6 shows a typical coaxial fixture that uses a standard beryllium oxide ring to conduct heat from the center conductor to the outside conductor of an air-dielectric line section. This type of arrangement is useful for power dissipation of 5 watts or less. A more efficient heat sink is obtained by use of a boron nitride cylinder that makes intimate contact between the coaxial-line conductors over the entire length of the cavity. This arrangement results in improved heat conduction, and, therefore, is more suitable for high-power microwave transistors. In addition, the boron nitride, which has electrical properties similar to those of beryllium oxide, is readily machinable and is nontoxic. Coaxial line lengths are also substantially reduced.

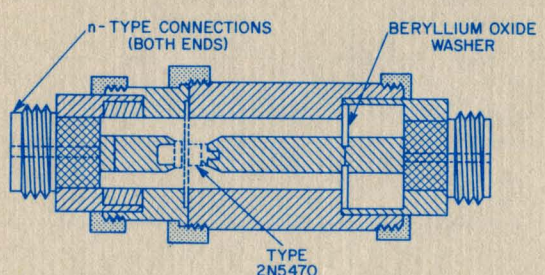


Fig. 6 — Typical fixture for use with a coaxial-package microwave power transistor.

2- and 2.3-GHz Power Amplifiers

Fig. 7 shows the circuit diagram for a typical microstripline power amplifier that uses an RCA-2N6267 transistor to develop a power output of 10 watts at 2 GHz. This amplifier is tunable by adjustment of variable capacitors C1 and C4. Similar circuits can be designed using the 2N6265 and 2N6266 transistors.

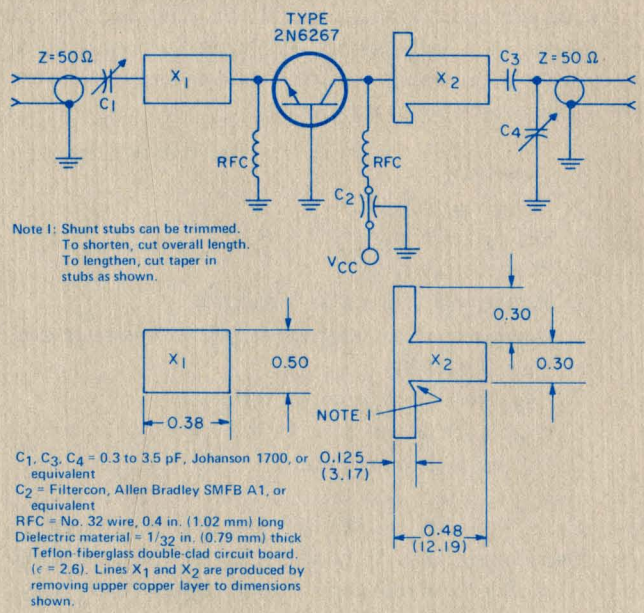

TYPE 2N6267
Z=50Ω
C1
X1
X2
C3
Z=50Ω
C4
RFC
RFC
C2
VCC
Note 1: Shunt stubs can be trimmed. To shorten, cut overall length. To lengthen, cut taper in stubs as shown.
0.30
0.50
0.30
0.38
NOTE 1
0.125 (3.17)
0.48 (12.19)
C1, C3, C4 = 0.3 to 3.5 pF, Johanson 1700, or equivalent
C2 = Filtercon, Allen Bradley SMFB A1, or equivalent
RFC = No. 32 wire, 0.4 in. (1.02 mm) long
Dielectric material = 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board. (ε = 2.6). Lines X1 and X2 are produced by removing upper copper layer to dimensions shown.

Fig. 7 — 2-GHz power amplifier using an RCA-2N6267 microwave power transistor.

Fig. 8 shows a similar amplifier circuit that uses the RCA-2N6267 to develop a power output of 8.5 watts at 2.3 GHz. This amplifier provides a power gain of 8 dB, operates at a collector efficiency of 35 per cent, and has a 1-dB bandwidth in the order of 100 MHz.

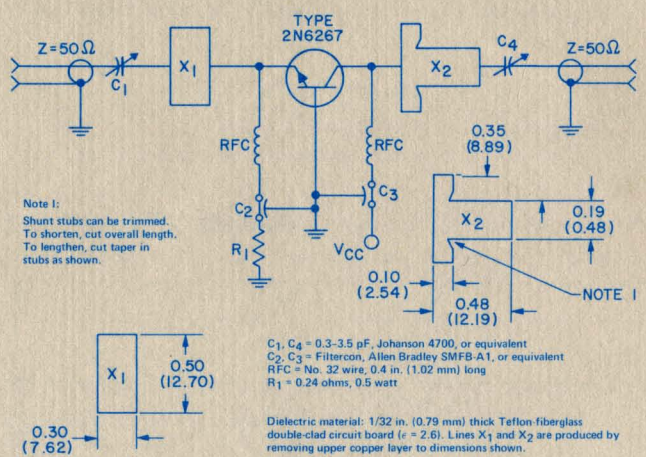

TYPE 2N6267
Z=50Ω
C1
X1
X2
C4
Z=50Ω
RFC
RFC
0.35 (8.89)
C2
C3
R1
VCC
Note 1:
Shunt stubs can be trimmed. To shorten, cut overall length. To lengthen, cut taper in stubs as shown.
0.19 (0.48)
0.10 (2.54)
0.48 (12.19)
NOTE 1
0.50 (12.70)
0.30 (7.62)
C1, C4 = 0.3-3.5 pF, Johanson 4700, or equivalent
C2, C3 = Filtercon, Allen Bradley SMFB-A1, or equivalent
RFC = No. 32 wire, 0.4 in. (1.02 mm) long
R1 = 0.24 ohms, 0.5 watt
Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board (ε = 2.6). Lines X1 and X2 are produced by removing upper copper layer to dimensions shown.

Fig. 8 — 2.3-GHz power amplifier using an RCA-2N6267 microwave power transistor.

12.5-Volt 960-MHz Amplifier for Land-Mobile Applications

The frequency band from 806 to 960 MHz is being considered for land-mobile communications to provide relief to the much congested frequency spectrum currently allo-

cated for two-way land-mobile as well as mobile telephone communications. The 2N6266 and 2N6267 microwave power transistors are highly suitable for this type of application. Because these devices are designed for 28-volt operation, they are extremely rugged when operated from a 12.5-volt supply. With a collector supply of 12.5 volts, the 2N6267 can deliver 10 watts of cw power at 960 MHz, as shown in Fig. 9. The 2N6266 can be used as a driver. Typical rf performance of the 2N6266 for operation at 12.5 volts is shown in Fig. 10.

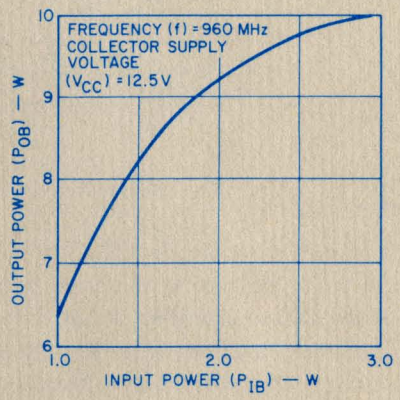


Fig. 9 — Typical rf performance of an RCA-2N6267 microwave power transistor at 960 MHz.

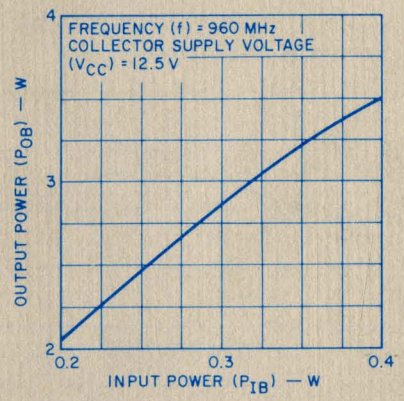


Fig. 10- Typical rf performance of an RCA-2N6266 microwave power transistor at 960 MHz.

Fig. 11 shows the basic circuit arrangement for an amplifier-multiplier chain that uses a 2N6266 driver and a 2N6267 output stage to develop 10 watts of output power at 960 MHz when operated from a collector supply of 12.5 volts.

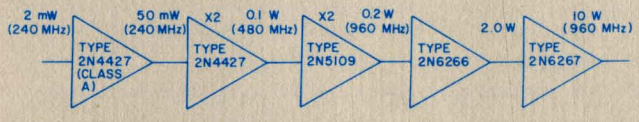


Fig. 11 — 960-MHz, 10-watt amplifier-multiplier chain for land-mobile applications.

Broadband Microwave Power Amplifiers

The sequence of steps in the design of any broadband amplifier are (1) determination of the input impedance and the optimum collector load impedance across the required frequency band for the power output (P_{out}), supply voltage (V_{CC}), power gain (PG), and efficiency (η_c) desired; (2) a review of the required transformation; and (3) selection of the basic transformation designs to be used. The application of this procedure to the design of three broadband microwave power amplifiers is shown in the following paragraph.

600-to-950-MHz Power Amplifier

Fig. 12 shows the circuit diagram for a power amplifier designed to operate over the frequency band from 600 to 950 MHz. This amplifier usus an RCA-2N6266 transistor that operates from a supply voltage V_{CC} of 28 volts to develop a cw power output of 10 watts. Performance data for this amplifier are shown in Fig. 13.

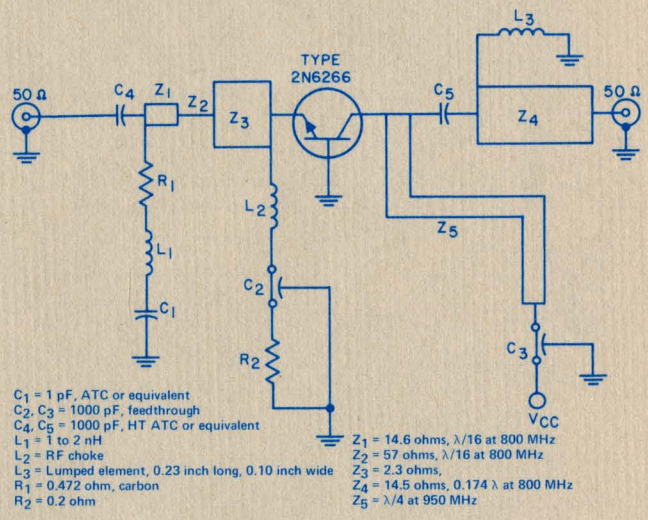


Fig. 12 — 600-to-960-MHz broadband power amplifier using the RCA-2N6266 microwave power transistor.

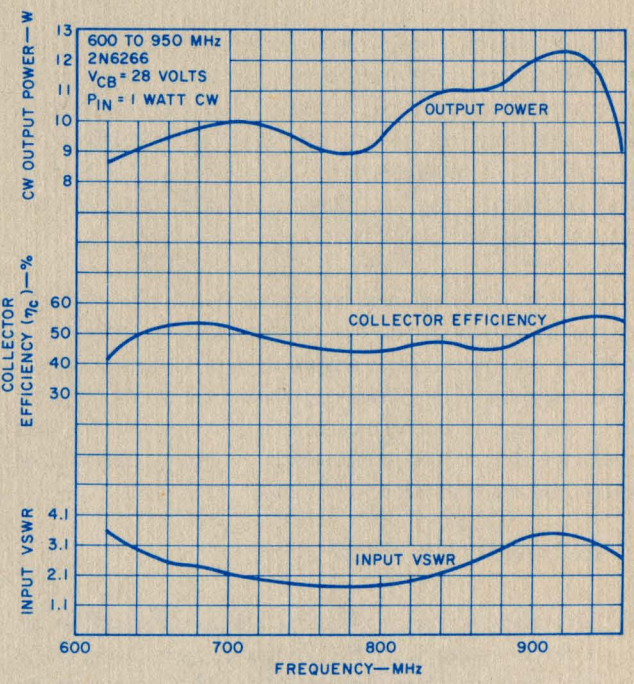


Fig. 13 — Performance data for the 600-to-950-MHz power amplifier.

Initially, the input impedance and the collector load impedance are measured under conditions of optimum efficiency (η_c) and power gain (PG) at a power output P_{out} of 10 watts. The Smith chart in Fig. 14 shows these measured impedance characteristics as a function of frequency. Input and output matching circuits are designed on the basis of these impedances. The input circuit consists of a four-stage sixteenth-wavelength ($\lambda/16$) short-step Chebyshev transformer [2] designed for a broadband transformation from 50 ohms to 1.5 ohms. The inductance of the transistor input impedance forms a portion of the last $\lambda/16$ Chebyshev step.

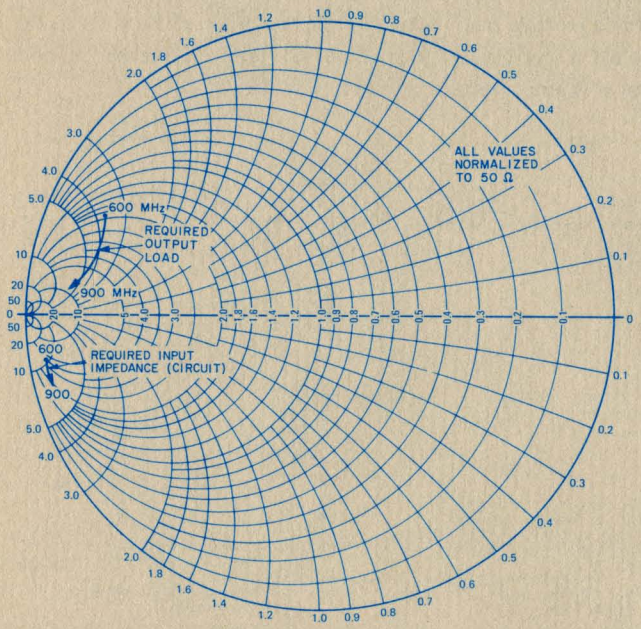


Fig. 14 — Impedance-admittance chart for the 600-to-950-MHz power amplifier.

Depending on the desired performance of the amplifier, the last $\lambda/16$ section of the transformer can be varied in length to provide an offset input VSWR that effectively flattens the gain response of the amplifier at either the high or the low end of the frequency band. The input circuit also uses a series resonant trap to flatten a gain peak at the high-frequency end of the band.

The required collector load impedance is inductive throughout the frequency band. The output circuit consists of a quarter-wavelength ($\lambda/4$) transformer and a shunt inductor at the collector. The values chosen for the shunt inductor and characteristic impedance of the $\lambda/4$ line yield a load impedance across the band which is very close to that required by the transistor.

1.0-to-1.4-GHz Amplifier

Fig. 15 shows the circuit diagram of a power amplifier designed for operation over the frequency band from 1.0 to 1.4 GHz. This amplifier uses an RCA-2N6267 transistor to develop a cw output of 15 watts. The transistor operates from a collector supply of 28 volts. Typical performance

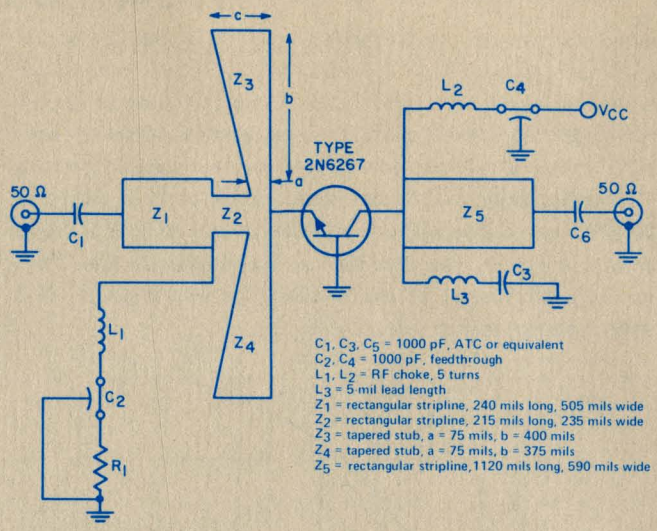


Fig. 15 — 1.0-to-1.4-GHz power amplifier using the RCA-2N6267 microwave power transistor.

data for this amplifier are shown in Fig. 16. The design of the output circuit is obtained by the same techniques as those used for the 600-to-950-MHz circuit. Fig. 17 shows the required transistor load and input impedances. Selection of the proper line characteristic impedance Z_o and shunt inductance L produces the same type of output matching as that obtained in the 600-to-950-MHz circuit. For the 1.0-to-1.4-GHz amplifier, the input transformation is provided by a short transformation from 50 ohms and a shunt capacitance stub at the transistor.

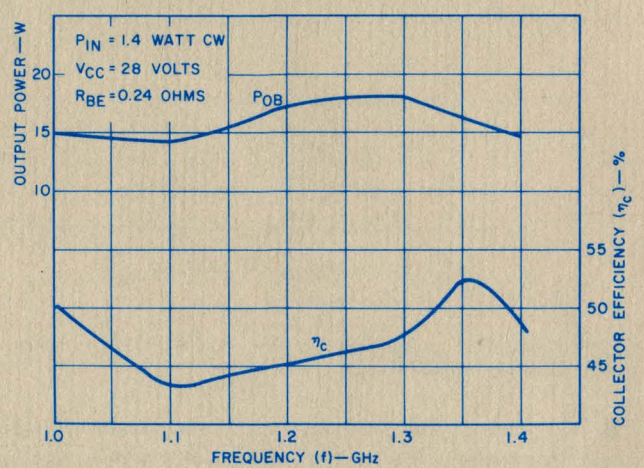


Fig. 16 — Performance data for the 1.0-to-1.4-GHz power amplifier.

960-to-1250-MHz Amplifier

The amplifier circuit shown in Fig. 18 is designed to operate over the frequency range from 960 to 1250 MHz in TACAN applications. It uses an RCA-2N6265 transistor to generate a cw power output of 2 watts across the band with a collector voltage of 28 volts. Typical performance data for this circuit are shown in Fig. 19. Because the real part of the required collector load is approximately 50 ohms, the only requirement is a shunt inductance L at the collector. The input circuit, which is similar to that of the 1.0-to-1.4-GHz circuit, consists of a short transformation and shunt capacitance C at the transistor.

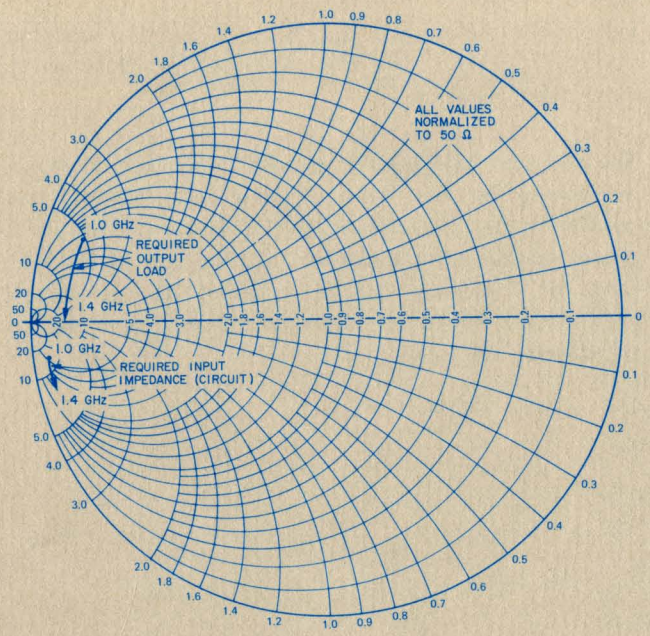
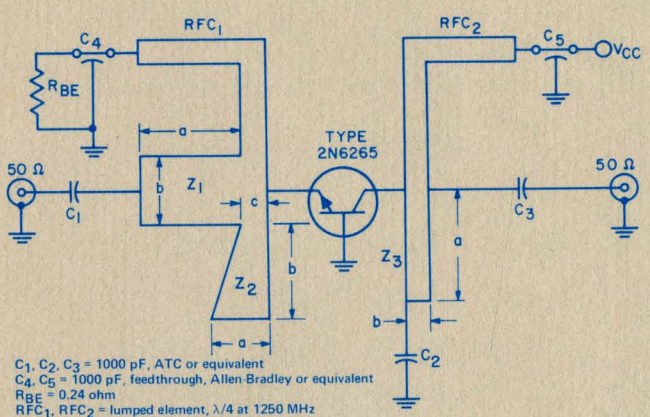


Fig. 17 – Impedance-admittance chart for the 1.0-to-1.4-GHz power amplifier.



C_1, C_2, C_3 = 1000 pF, ATC or equivalent
C_4, C_5 = 1000 pF, feedthrough, Allen-Bradley or equivalent
R_{BE} = 0.24 ohm
RFC_1, RFC_2 = lumped element, λ/4 at 1250 MHz
Z_1, = stripline, a = 1060 mils, b = 227 mils
Z_2, = stripline, a = 775 mils, b = 450 mils, c = 80 mils
Z_3 = stripline, a = 500 mils, b = 100 mils

Fig. 18 – 960-to-1250-MHz power amplifier using the RCA-2N6265 microwave power amplifier.

1.7-GHz Microstripline Power Oscillator

The design of microwave power oscillators is usually a complex process because of the many diverse requirements that must be met in these circuits. The design of the power oscillator shown in Fig. 20, however, is made relatively simple by application of power-amplifier considerations. This oscillator uses an RCA-2N6267 microwave power transistor to develop a typical power output of 4.0 watts at 1.7 GHz when operated from a collector supply of 20 volts. A power output of 2.3 watts at 1.6 GHz can be obtained when the transistor is operated from a collector supply of 12.5 volts. The collector efficiency in each case is in the order of 37 per cent.

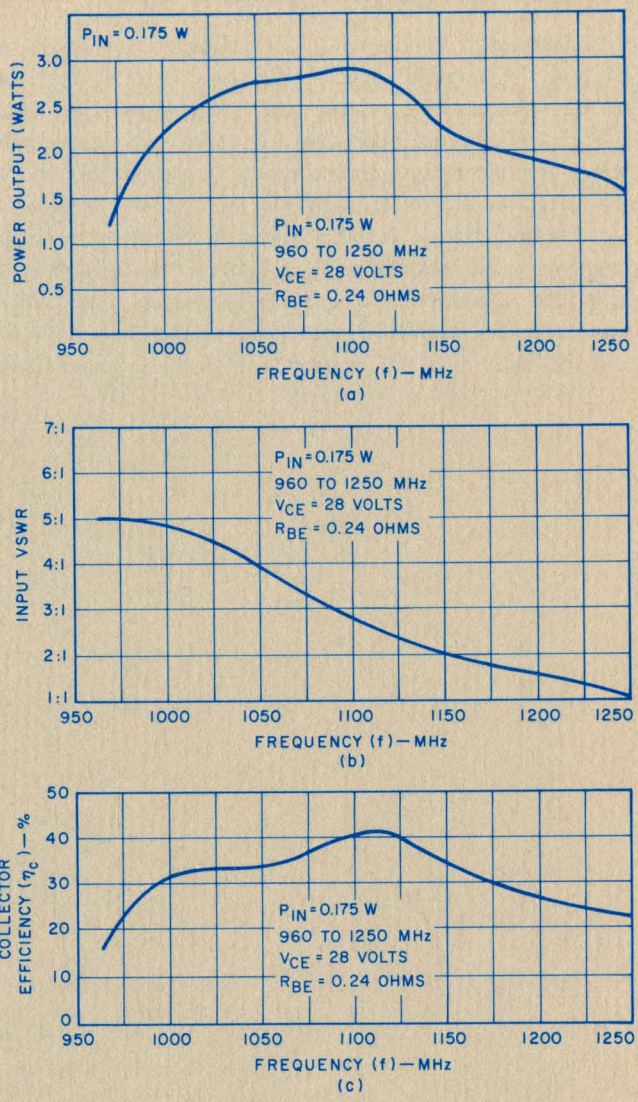
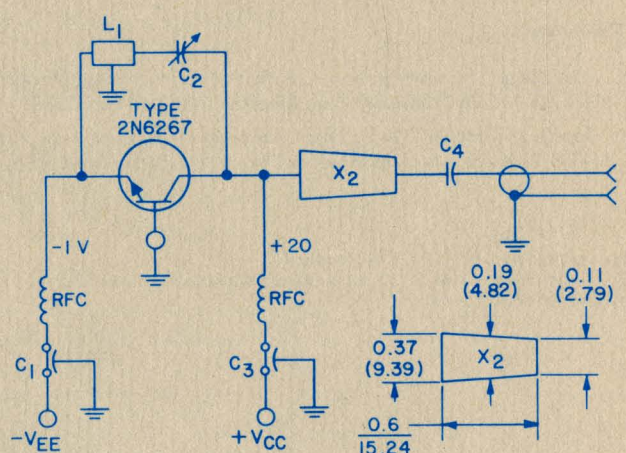


Fig. 19 – Performance data for the 960-to-1250-MHz power amplifier.



C_1, C_3 = Filtercon, Allen Bradley SMFB-A1, or equivalent
C_2 = 0.3-3.5 pF, Johanson 4700, or equivalent
C_4 = 300 pF, ATC-100 or equivalent
L_1 = 1.0 in. section miniature 50-ohm cable, or microstripline equivalent
RFC = 3 turns, No. 32 wire 1/16 in. ID, 3/16 in. long
X_2 = 13 mill thick Teflon-Kapton double-clad circuit board (Grade PE-1243 as supplied by Budd Polychem Division, Newark, Delaware or equivalent
Line X_2 is exponentially tapered
NOTE: Oscillator is single-screw tunable from 1.6 GHz to 1.8 GHz

Fig. 20 – Typical 1.7-GHz power oscillator using the RCA-2N6267 microwave power transistor.

In the design of the oscillator, the values of the line section L1 and the variable capacitor C2 are chosen so that the resonant frequency of these elements is slightly less than the desired circuit operating frequency. At frequencies above resonance (e.g., the oscillator operating frequency), the combination of L1 and C2, in essence, becomes a variable inductance L. The transistor input and output reactances, the inductance L, and the transistor collector-to-emitter capacitance C_{CE} form a resonant circuit that establishes the oscillation frequency of the over-all circuit and also determines the correct level of the in-phase signal fed back to the input to sustain oscillation. The operating frequency of the oscillator is controlled by adjustment of the variable capacitor C2.

The real part of the collector load impedance, $Re(Z_{CL})$, determined on the basis of large-signal class C load conditions, is transformed to 50 ohms by use of a quarter-wavelength transformer X2. Because of the wide range of frequency control provided by the variable capacitor C2, a quarter-wavelength tapered line is used for transformer X2.

References

1. J. R. Black,"Electromigration – A Brief Survey of Some Recent Results," IEEE Transactions on Electron Devices, April 1969.
2. George L. Mathaei, "Short Step Chebyshev Impedance Transformers," IEEE Transactions on Microwave Theory and Techniques, August 1966.

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